1990 Annual Report to the Office of Naval Research

Grant #: N00014-89-J-1202
Grant Title: Large Motions of the Magnetization in Magnetically Ordered Media
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Progress was made during the grant period 1 October 1989 through 30 September 1990 in two main areas: 1. Self-organization of magnetic domain structures into critical states, and 2. Domain wall motion in ferromagnets.

1. Our previous findings, that in many situations, elaborate micromagnetic computer calculations of domain structures are neither necessary, nor particularly revealing, were further documented by comparison with experiment. One set of experiments concerns the magnetic configurations assumed by arrays of small magnetic particles. A primitive algorithm, such as was employed in the discussion of so-called zig-zag domains (see Che & Suhl, Phys. Rev. Lett. **64**, 1670, 1990) gives good agreement with the observed patterns. Furthermore, the demagnetizing process carried out on such an array and its dependence on particle density was excellently simulated by the same algorithm. The reason why such a crude procedure works well is that in these situations, the preferred state of the system is critical in the sense that it becomes independent of some of the physical parameters that normally govern its behavior. We have also applied these ideas to the problem of noise in magnetic recording, and can account for the observed trends at least qualitatively. This work has been submitted for publication (Che and Suhl, JAP, submitted). Currently, we are examining the question of erasibility of magnetically recorded information using the same methods, and have some preliminary results. On the level of fundamental properties of the self-organized critical state, we have extended our previous scaling results to finite-size scaling. This work is about to be submitted for publication. An overview of these results is to be presented in two invited papers, one at the 35th Conference on Magnetism and Magnetic Materials, the other at the 1990 Fall Meeting of the Materials Research Society.

2. Domain wall motion.

A new approach to the motion of magnetic domain walls was developed. The new physical effect that had not heretofore been noticed is that a wall moving with a certain critical speed must amplify thermal spin waves (or spontaneously emit spin-wave quanta, if the temperature is so low that this is important). The energy for the process must come from the wall motion. As the result, the wall velocity saturates and does not increase further with increasing driving field. The critical spin waves are those whose group velocity is equal to their phase velocty, and this common velocity is also equal to the saturation wall velocity. (Synchronism effects of this kind are, of course, familiar elsewhere in physics, e.g. Landau damping in plasmas.) This work, including comparison with experiment, has been submitted to Phys. Rev. Letters.

Without reference to thermal excitation or spontaneous emission, the state of the wall can also be described in the language of nonlinear dynamics as a "fixed point." We expect to find higher fixed points (including limit cycles such as are sometimes observed as oscillations of moving walls) as the driving field is further increased.

OFFICE OF NAVAL RESEARCH
PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS REPORT
1 Oct 89 through 30 Sept 90

R&T Number: 4123033---04

Contract/Grant Number: N00014-89-J-1202

Contract/Grant Title: Large Motions of the Magnetization in Magnetically Ordered Media

Principal Investigator: Harry Suhl

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Phone Number: (with Area Code) (619) 534-4748

E-Mail Address: (not checked on a regular basis)

a. Number of Papers Submitted to Refereed Journal but not yet published: 3

b. Number of Papers Published in Refereed Journals: 2 (list attached)

c. Number of Books or Chapters Submitted but not yet Published: 1

d. Number of Books or Chapters Published: 1 (list attached)

e. Number of Printed Technical Reports & Non-Refereed Papers: 0 (list attached)

f. Number of Patents Filed: 0

g. Number of Patents Granted: 0 (list attached)

h. Number of Invited Presentations at Workshops or Prof. Society Meetings: 0

i. Number of Presentations at Workshops or Prof. Society Meetings: 0

j. Honors/Awards/Prizes for Contract/Grant Employees:
(list attached, this might include Scientific Soc Awards/Offices, Promotions, Faculty Awards/Offices etc)

k. Total number of Graduate Students and Post-Docs Supported at least 25% this year on this contract/grant:

Grad Students 3 and Post-Docs 0 including

Grad Student Female 0 and Post-Docs Female 0

Grad Student Minority 0 and Post-Doc Minority 0

Minorities include Blacks, Aleuts, AmIndians, Hispanics etc. NB: Asians are not considered an under-represented or minority group in science and engineering.

b. Papers Published in Refereed Journals:

Paul Bryant and Harry Suhl, "Micromagnetics Below Saturation," J. Appl. Phys. **66**, 4329 (1989).

Xiaodong Che and Harry Suhl, "Magnetic Domain Patterns as Self-Organizing Critical Systems," Phys. Rev. Lett. **64**, 1670 (1990).

d. Books or Chapters Published:

H. Suhl, "Pattern Formation and Self-Organization in Magnetic Systems." In *New Trends in Magnetism*, Proceedings of Conference, Recife, Brazil, 26-28 July, 1989, eds. Mauricio D. Coutinho-Filho and Sergio M. Rezende (World Scientific, Teaneck, NJ, 1989).